

## LETTERS

Kelp forests serve as early indicators that portend climate impacts in other marine ecosystems.

Edited by Jennifer Sills

## Marine heat waves threaten kelp forests

Marine kelp forests, among the most productive ecosystems on our planet (1), are in danger. The increase in the frequency and intensity of extreme climatic events (2) such as marine heat waves is compromising kelp forests' capacity to produce goods and services (such as biomass of commercial fisheries, coastal protection, nutrient cycling, carbon sequestration, and recreational opportunities) that are worth billions of dollars to humanity (3). However, despite increasing climate-change advocacy and the overwhelming evidence demonstrating social and ecological impacts of climate change (4), political denial and inaction are jeopardizing society's ability to respond adequately to the multifaceted consequences of the accelerating pace of climate-driven loss of marine forests.

Between 2014 and 2016, extreme marine heat waves of unprecedented duration and magnitude in the northwestern Pacific Ocean decimated giant kelp forest ecosystems across the U.S. state of California and Baja California, Mexico (5–7). Three years later, the once-extensive giant kelp forests have not recovered. Many of these underwater forests are now gone, replaced by smaller kelps or by sea urchin “barrens” (7), which can no longer provide food and shelter to diverse ecological communities. Meanwhile, at the UN climate conference COP25, the international community lost a valuable opportunity to tackle the climate

crisis, mainly due to the lack of ambitious commitments by major players who are denying scientific evidence (8).

Kelp forests embody the concept of “sentinel systems” (early indicators) in the face of climate change. Their loss is an emergent global conservation issue (9) that signals future impacts throughout the marine realm. If political authorities fail to support climate-smart strategies (10), substantial economic losses will follow. Alarming, CO<sub>2</sub> emissions continue a trend of increase (11); unless this trend is reversed, studies predict a near-permanent marine heat wave status by the end of the 21st century (12).

We urgently need international agreements to decrease future global CO<sub>2</sub> emissions as well as government policies to mitigate existing local threats. Countries need to prioritize science-based mitigation and adaptation solutions, including improved management of anthropogenic impacts unrelated to climate change, the development of sea urchin markets and ranches, the exploration of climate-safe restoration sites, and the identification of genetically resilient kelp stocks. These changes will require investment in research and environmental protection. Increased human capacity will also be needed to halt and reverse the ongoing rapid loss of ecosystems and their services to people.

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## Marine restoration projects are undervalued

Coral reefs, mangroves, and seagrass beds support the livelihoods of many millions of people worldwide. These ecosystems are rapidly degrading, leading governments and foundations to dedicate billions of dollars to their active restoration. Such initiatives are often criticized for being too small in scope and too expensive to combat the extent of anthropogenic threats driving habitat loss [e.g., (1, 2)]. However, this criticism undervalues key attributes of restoration projects that are not contingent on spatial scale.

Restoration accelerates the recovery of biological communities at local scales. Although restored habitats remain vulnerable to subsequent disturbance events, their biodiversity has the potential to increase ecosystem resilience of larger areas by providing seed material for recovery (3). Restoration can also counter the economic, socio-cultural, and psychological impacts of habitat degradation for local communities (4), even if techniques are too expensive to upscale globally. The pessimistic view of marine restoration as a fruitless exercise differs from attitudes about the rehabilitation of forest habitats that suffer equivalent large-scale degradation. Generally, socio-economic, ecological, and cultural values

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are appreciated in tree planting, whether it involves a few saplings or millions (5, 6).

Political agreements for global reductions in atmospheric carbon have been slow to emerge. Relying on their implementation as the only solution to the degradation of tropical habitats is a major gamble. In the meantime, restoration projects could help maintain species survival and ecosystem services, ultimately providing humanity with the breathing space to stabilize the climate.

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## U.S. action lowers barriers to invasive species

Invasive species can cause harm to a broad spectrum of critical needs ranging from economic, food, water, and infrastructure security to human and environmental health to military readiness (1). However, recent actions by the Trump Administration put national security at risk by lowering barriers to these devastating invaders. Department of the Interior officials cut the National Invasive Species Council (NISC) budget by 50% (2) and terminated the associated Invasive Species Advisory Committee (ISAC) (3), effectively crippling the ability of federal agencies to work with each other and with nonfederal stakeholders to address invasive species. The United States needs comprehensive, robust, consistent actions to minimize impacts of invasive species that already cost the nation hundreds of billions of dollars annually (4).

The biological invasion crisis is best addressed by using education, regulation, and border control to prevent invasive species from entering the country. Action must be taken to quickly detect and intercept nonnative species at points of entry. This responsibility largely falls to the federal government. The meager NISC budget—just \$1.2 million per year (5)—was already grossly insufficient given the importance of its mission; invasive species have been found to be as disruptive as climate change (6). Prioritizing protection from invasive species is a good investment;

preventing entry of a single new high-impact invasive species could save billions of dollars annually (7). Yet the recent cuts make clear that the U.S. government will fail to adequately prioritize prevention at ports of entry, to assess the impacts of invasive species on the economy and human health, and to implement an effective national early detection-rapid response program.

Invasive species affect every sector of the nation regardless of jurisdiction or politics. Climate change, international trade, and resource use will further facilitate invasions. The public, nongovernmental organizations (NGOs), and scientific communities must demand that the federal government build upon the vision for high-level, well-coordinated federal leadership by restoring the NISC budget, reestablishing ISAC, and increasing support for actions by NGOs and state and local governments. U.S. lands and waters face unprecedented risks from our current porous biosecurity policies.

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#### COMPETING INTERESTS

J.K.R. previously served as the National Invasive Species Council's executive director and assistant director for policy, science, and cooperation. J.K.R. also served on the Invasive Species Advisory Committee for 6 years.

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